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Effect of breed-type on performance and carcass traits of intensively managed hair sheep

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Abstract

The objectives of this study were to evaluate growth performance and carcass characteristics of intensively managed purebred and crossbred hair sheep, and determine the value of the Dorper breed as a terminal sire on St.Croix and St. Croix-cross dams. Animals used were Dorper×St. Croix (DS), and Dorper×Romanov×St. Croix (DX), Katahdin (KA), St. Croix (SC), and 3/4 St. Croix-$\frac{1}{4}$ Romanov (SX) wether lambs. From birth to weaning, daily gains (ADG) were greater ($P<0.01$) for DS and KA lambs than SC and SX lambs; yet, from weaning to harvest, ADG was greatest ($P<0.01$) for DS, followed by DX, SC, SX, and KA lambs. Carcass weights were heavier ($P<0.01$) for DS than all other breeds and DS, DX, KA, and SX carcasses had greater ($P<0.01$) fat thickness measurements than SC carcasses. The *longissimus thoracic* (LT) area was largest ($P<0.01$) for DS and DX carcasses and smallest ($P<0.01$) for SC and SX carcasses. Skeletal, lean, and overall maturities were similar ($P>0.10$) among the breed types; however, carcasses from SC lambs received lower ($P<0.02$) flank streaking scores than DS, KA, and SX lambs. Conformation scores and quality grades were greater ($P<0.01$) for DS and DX than SC or SX carcasses. Although L^* values of the LT were similar ($P>0.10$), the LT from DX lambs was redder ($P<0.01$) and more yellow ($P<0.01$) than that of DS and SC lambs. The shear force values of the LT chops from KA lambs were greater ($P<0.01$) than all other breed types. Results indicate that improvements in live animal performance, carcass muscularity, and quality can be achieved by using Dorper sires on purebred and crossbred St. Croix dams. Published by Elsevier Science Ltd.

Keywords: Hair sheep; Growth; Carcass traits; Quality; Shear force

1. Introduction

There is a desire to incorporate an easy-care animal into small to mid-size sustainable production systems. Hair sheep possess desirable attributes as they shed their hair/wool coat and may be more tolerant to intestinal parasites than most wool breeds (Courtney, Parker, McClure, & Herd, 1985; Gamble & Zajac, 1992; Wildeus, 1997; Zajac, Krakowka, Herd, & McClure, 1990); however, growth rate and mature size of hair sheep is less than that of traditional breeds of wool sheep (Wildeus, 1997).

Little information is available on growth performance of hair sheep in the USA, but, in other countries, growth rate is generally lower due to low-input management systems and environmental stressors to which they have been exposed (Wildeus, 1997). Growth rates for St. Croix and Barbados Blackbelly lambs fed high concentrate diets were lower than wool and hair×wool lambs (Ockerman, Emsen, Parker, & Pierson, 1982; Foote, 1983; Phillips, Von Tungeln, & Brown, 1995), and feed efficiency of wool and hair×wool lamb was similar to, or greater than, hair breed (Pineda, Palma, Haenlein, & Galina, 1998; Wildeus, 1997). In contrast, Horton and Burgher (1991) reported that average daily gain and feed-to-gain ratios were similar between Katahdin (hair sheep breed) and Dorset (wool breed).

Carcass characteristics of Dorper×Columbia (hair×wool) crossbred lambs were similar to Suffolk ×Columbia (wool×wool) lambs (Snowder, 1999). Additionally, Nell (1998) reported that Dorper×Rambouillet (hair× wool) lambs produced heavier carcasses of greater value compared to purebred Rambouillet and Suffolk× Rambouillet (wool×wool)

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crossbred lambs. Moreover, lamb from Dorper-sired wethers was more tender (Duckett, Cuvala, & Snowder, 1999) than lamb from Suffolk-sired wethers.

St. Croix lambs have found a place in ethnic markets, but, because of their small size, St. Croix lambs are discriminated against in traditional lamb markets. Dorper lambs, on the other hand, are larger and may be more suited for marketing along with typical wool breeds of sheep; however, very little is known about the growth rate and carcass characteristics of this hair sheep breed under US production systems. Therefore, the objectives of this study were to evaluate growth performance and carcass characteristics of intensively managed purebred and crossbred hair sheep, and determine the value of the Dorper breed as a terminal sire on St. Croix and St. Croix-cross dams.

2. Materials and methods

All experimental procedures were reviewed and approved by the Agricultural Research Service Animal Care and Use Committee in accordance to National Institute of Health guidelines for Care and Use of Laboratory Animals. Pain and stress to sheep were minimized throughout the experiment.

2.1. Animals and experiment

Hair sheep breeds evaluated were Dorper×St. Croix (DS; $n=7$), Dorper×Romanov×St. Croix (DX; $n=9$), Katahdin (KA; $n=15$), St. Croix (SC; $n=8$), and 3/4 St. Croix-$\frac{1}{4}$Romanov (SX; $n=8$) wethers. Lambs were born between January and March 2000. Dorper- and St. Croix-sired lambs were born at the Agricultural Research Service (ARS) research farm in Booneville, AR; whereas, Katahdin lambs were purchased from a local producer at weaning. There was one St. Croix and four Dorper sires used to produce offspring from St. Croix or St. Croix×Romanov ewes. Birth weights of all lambs were recorded by ARS personnel, and lambs were pasture-raised as twins in the absence of creep feed until weaning. Body weight was measured at weaning (between 58 and 66 days of age) and at 28-day intervals between weaning and harvest to calculate average daily gain (ADG). Lambs were housed in an open-sided barn with concrete floors and had ad libitum access to water. A total mixed diet was offered to lambs and increased incrementally over a 30-day period; thereafter, the diet was offered ad libitum for 20-days. The finishing diet was formulated for moderate growth potential according to NRC (1985) requirements and crude protein was 16.9%. The finishing diet consisted of 37.3% cracked corn, 15.8% wheat middlings, 14.1% soybean meal (44% CP), 12.7% cottonseed hulls, 10.0% dehydrated alfalfa pellets (17% CP), 4.1% cane molasses, 3.8% soybean hulls, 1.1% limestone, 0.49% salt, 0.5% ammonium chloride, 0.15% trace mineral and vitamin premix, and 27.5 mg/kg lasalocid.

At a mean of 207 days of age, lambs were weighed and transported 151 km to the University of Arkansas Red Meat Abattoir. Feed and water were withheld from lambs overnight (approximately 12 h) before harvest. Lambs were rendered unconscious and insensitive to pain by captive-bolt stunning, and subsequently harvested according to industry-accepted procedures. Hot carcass weight was recorded, and carcasses were chilled for 7 days at 2 °C before carcass data collection and fabrication. Carcass quality grade data (USDA, 1992) were collected by an experienced evaluator. Carcasses then were ribbed between the twelfth and thirteenth thoracic vertebrae and yield grade data were collected. The area of the *longissimus thoracic* (LT) muscle was traced upon acetate paper and measured with a compensating planimeter, and body wall thickness was measured 7.5 cm distal to the ventral end of the LT.

Carcasses were weighed and all kidney and pelvic fat (with kidneys) was removed from each carcass and weighed. Percentage kidney and pelvic fat was calculated as percentage of chilled carcass weight. Cooler shrinkage was calculated by dividing the difference between the hot and chilled carcass weights by the hot carcass weight. Carcasses were then fabricated into primal cuts according to National Association of Meat Purveyors (NAMP) specifications (NAMP, 1992) for lamb. The primal rack (NAMP #204) was further processed into 2.5-cm thick chops. Percent retail product yield was calculated (49.94−(0.085×hot carcass wt, lb)−(4.376 adjusted fat thickness, in)−(3.53×body wall thickness, in) + (2.456 ×*longissimus thoracic* area, sq. in; unpublished equation, K. Belk and J.W. Savell, j-savell@tamu.edu). Instrumental color of two rack chops was measured with a Hunter MiniScan XE (Model 45/0-L, Hunter Associates Laboratory, Inc., Reston, VA) after a 30-mm "bloom" period at 4 °C. Commission Internationale de l'Eclairage (CIE, 1976) L^*, a^*, and b^* values were determined from the mean of six readings (three from each chop) using illuminant C and a 10° standard observer. The saturation index represents the chroma, or total color, of the LT and was calculated $\sqrt{a^{*2}+b^{*2}}$ (Minolta, 1993).

The remaining LT chops from the primal rack were individually weighed, then cooked to an internal temperature of 71 °C in a Blodgett convection oven (Blodgett Oven Co., Burlington, VT) preheated to 165 °C. Thermocouples were inserted into the geometric center of each chop, and endpoint temperature was monitored with a multi-channel data recorder (VAS Engineering Inc., San Diego, CA). Chops were allowed to cool to room temperature, blotted dry with paper towels, and reweighed. The difference between precooked and cooked weight was divided by the precooked weight to calculate cooking loss percentages. Then, five 1.27-cm diameter cores were removed (1–2 cores/chop depending on chop size) parallel to the muscle fiber orientation, and sheared once through the center with a Warner–Bratzler shear apparatus (in compression) attached to an Instron 4466 (Instron Corp., Canton, MA) with a 55-kg load cell and a crosshead speed of 250 mm/min.

2.2. Statistical analyses

All data were analyzed using PROC GLM (SAS, 1990), with breed-type as the main effect in the model. Body weight change over the course of the experiment was analyzed using heterogeneity of regression, as described by Wilcox, Thatcher, and Martin (1990). Least squares means were computed for each breed type and separated statistically using the PDIFF option of SAS (1990).

3. Results and discussion

3.1. Live animal performance

Birth weights were similar ($P > 0.10$) among the breed types, but KA lambs had heavier ($P < 0.05$) weaning weights than DX, SC, and SX lambs (Table 1). This could reflect a difference in pre-weaning management between the ARS flock and the local Katahdin producer. The DS lambs were heavier ($P < 0.05$) at harvest than DX, KA, SC, and SX lambs. Average daily gain from birth to weaning was greatest ($P < 0.05$) for DS and KA lambs and lowest ($P < 0.05$) for SC and SX lambs; however, DS lambs had the highest ($P < 0.05$), and KA lambs the lowest ($P < 0.05$), ADG from weaning to harvest (Table 1; Fig. 1).

Very little information exists comparing the performance of hair sheep breeds. Schwulst and Martin (1995) reported that Katahdin-sired lambs had similar birth and weaning weights to Rambouillet- and Tunis-sired lambs, but Katahdin lambs had the lowest pre-weaning ADG in 2 out of 3 years of the study. St. Croix lambs were heavier at birth than Barbados Blackbelly and Florida Native lambs, but pre-weaning ADG and weaning weights were similar across the three hair sheep breeds (Godfrey, Gray, & Collins, 1997). Although weaning weights for DS and DX lambs in this experiment were lower than published values for Dorper and Dorper-crossbred lambs (Cloete, Snyman, & Herselman, 2000), the pre-weaning ADG was similar to that of Basson, Van Niekerk, and Mulder (1970) and Schoeman and Burger (1992).

Post-weaning gains of KA lambs in the current study could have been reduced relative to their originating flock mates due to stress of new environment and exposure to potentially new microorganisms introduced at the Booneville location, which could have led to reduce ADG compared with SC lambs. In contrast, Wildeus, Solomon, Mitchell, Eastridge, and Collins (2001) reported similar post-weaning gains between Katahdin and St. Croix lambs on a moderate growth diet. In addition, post-weaning gains of Katahdin lambs were greater than Rambouillet, Tunis, or Romanov lambs when fed a high-concentrate finishing diet (Schwulst & Martin, 1995). Additionally, the ADG of Katahdin and Dorset (wool breed) lambs were similar, but greater than St. Croix lambs (Horton & Burgher, 1992). Several studies have shown that St. Croix lambs were slower growing and less efficient than wool breed and hair×wool crossbred lambs (Phillips et al., 1995; McClure & Parker, 1991; Ockerman et al., 1982). On the other hand, the Dorper breed, developed in South Africa primarily for meat production by crossing horned Dorset rams on Black-headed Persian ewes, has been shown to have performance characteristics similar to that of wool sheep breeds (Cloete et al., 2000). Basson et al. (1970) reported that Dorper lambs had higher ADG than Dohne Merino and Merino lambs, and Von Seydlitz (1996) found that Dorper-sired lambs gained weight more rapidly than Karakul- and Damara-sired lambs from birth to harvest.

Table 1
Least squares means for growth performance of Dorper × St. Croix (DS), Dorper × Romanov × St. Croix (DX), Katahdin (KA), St. Croix (SC), and 3/4 St. Croix-1/4 Romanov (SX) wethers[a]

Item	Hair sheep breeds					Pooled SE
	DS	DX	KA	SC	SX	
Number	7	9	15	8	8	
Birth weight, kg	3.6	3.0	3.6	3.0	3.1	0.16
Weaning weight, kg	18.9wx	16.1xy	19.2w	13.7y	14.4y	0.95
Harvest weight, kg	56.4w	49.5x	44.8y	43.7y	42.8y	5.76
Average daily gain, g/day						
Birth to weaning	240.1w	223.8wx	235.7w	184.5x	190.1x	13.64
Weaning to harvest	246.5w	225.8x	180.8z	204.6xy	192.7yz	8.42

[a] w,x,y,z within a row, least squares means lacking a common letter differ ($P < 0.05$).

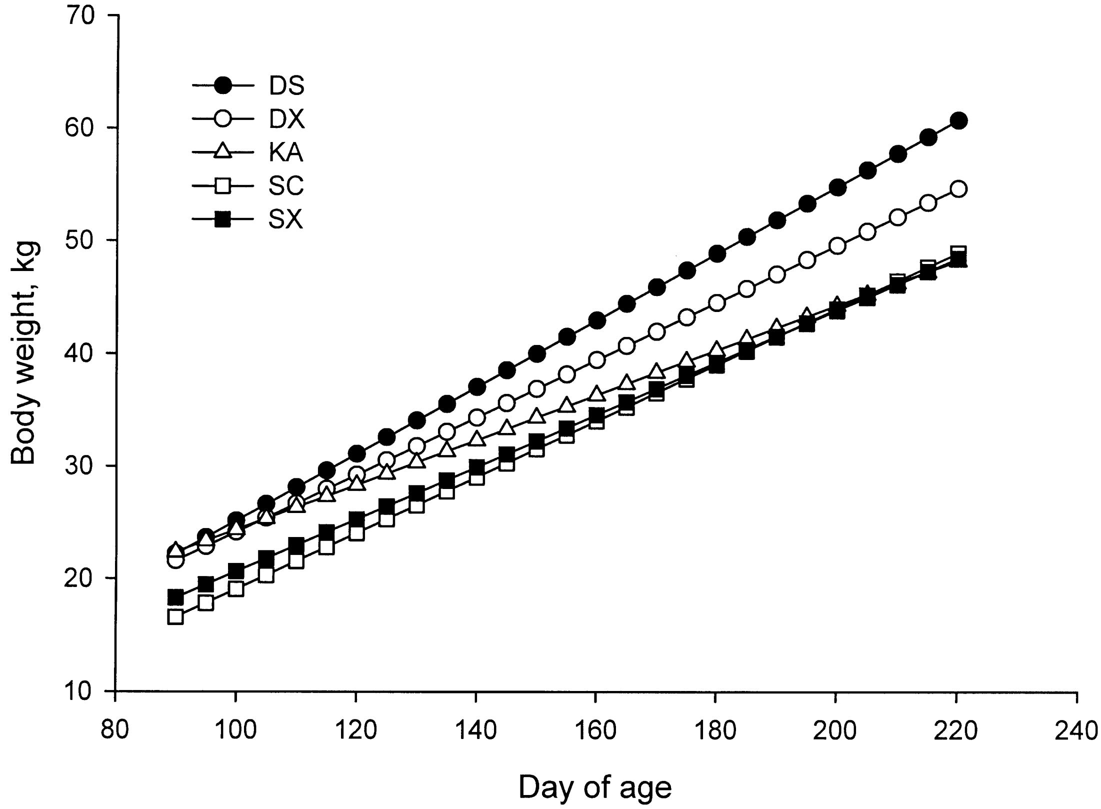

Fig. 1. Predicted body weight change of Dorper × St. Croix (DS; closed circles), Dorper × St. Croix × Romanov (DX; open circles), Katahdin (KA; open triangles), St. Croix (SC; open squares), and St. Croix × Romanov (SX; closed squares) wether lambs. Regression lines are presented for each breed-type during the high-energy feeding (from approximately 90 days of age to harvest at approximately 210 days of age) with predicted weight increase each day.

3.2. Carcass yield

The effects of breed-type on carcass cutability characteristics are presented in Table 2. Carcasses from DS lambs were the heaviest ($P<0.01$), whereas SC and SX lambs produced the lightest ($P<0.01$) hot carcass weights. Yet, carcasses from KA lambs had higher ($P<0.01$) dressing percentages than carcasses from SC and SX lambs. After the 7-day aging period, carcasses from DS and DX lambs were still heavier ($P<0.01$) than those from SC and SX lambs; however, the higher dressing percent of KA carcasses led to reduced ($P<0.01$) percentage of weight lost during aging compared to carcasses from DX, SC, and SX lambs.

The actual fat thickness measurements, as well as carcass yield grade, of SC carcasses were less ($P<0.01$) than carcasses from the other hair sheep breed-types. Although the weight of kidney and pelvic fat was similar ($P>0.10$) among breed-types, the percentage of kidney fat from SX carcasses was greater ($P<0.01$) than that of carcasses from DS, DX, and KA lambs.

Published data concerning differences in external fat thickness in hair and wool breeds of sheep are not consistent. St. Croix lambs had less external fat than carcasses from Targhee (McClure, Parker, & Parrett, 1991; Solomon, Horton, McClure, Paroczay, Mroz, & Lough, 1991), Suffolk×St. Croix, Gulf Coast Native×St. Croix (Godfrey & Collins, 1999), and Florida Native (Foote, 1983) lambs, but fat thickness was not different between carcasses of St. Croix, Barbados, Finnsheep and St. Croix crossbred lambs (Ockerman et al., 1982). Snowder (1999) found that carcasses of Dorper-sired lambs were similar in external fatness to Suffolk-sired lambs, especially over the 12th rib and rump, producing carcasses with comparable yield grades. Furthermore, it is apparent from the available literature that hair sheep tend to have a greater percentage of internal fat. Carcasses from St. Croix, Katahdin, and Barbados lamb had considerably more internal fat than carcasses from Dorset lambs (Boyd, 1983; Shelton, 1983; Horton & Burgher, 1992). However, Solomon et al. (1991) reported the percentage of kidney and pelvic fat for carcasses from St. Croix and Targhee (wool) lambs was identical.

Dorper-sired lambs produced carcasses with larger ($P<0.01$) LT areas than carcasses from St. Croix-sired lambs; the LT area of KA carcasses was similar to that

Table 2
Least squares means for carcass cutability characteristics of Dorper × St. Croix (DS), Dorper × Romanov × St. Croix (DX), Katahdin (KA), St. Croix (SC), and **3/4** St. Croix-V_4 Romanov (SX) wethers[a]

Item	Hair sheep breeds					Pooled SE
	DS	DX	KA	SC	SX	
Hot carcass weight, kg	29.9w	25.9x	24.1xy	21.6y	21.5y	3.87
Dressing percentage,%	52.8wx	52.1wx	53.7w	49.0y	50.2xy	3.11
Chilled carcass weight, kg	28.6w	24.7x	23.5xy	20.3z	20.4yz	3.71
Cooler shrinkage,%	4.2wx	4.7w	2.4x	5.6w	5.4w	2.06
Actual fat thickness, mm	75w	6.9w	5.9w	3.4x	5.9w	2.17
Body wall thickness, mm	16.8	16.4	17.5	14.7	16.8	3.26
Kidney fat weight, kg	1.6	1.4	1.4	1.3	1.5	0.44
Kidney fat,%[b]	5.4x	5.6x	5.8x	6.3wx	7.1w	1.34
Longissimus thoracis area, cm^2	15.5w	14.9wx	13.5x	11.0y	10.5y	1.87
Longissimus thoracis area, cm^2/kg	0.552wx	0.607w	0.579wx	0.545wx	0.525x	0.0206
Yield grade[c]	5.0x	4.6x	4.3x	2.9w	4.3x	1.17
Retail product yield, %[d]	46.6	47.3	47.1	47.5	46.6	1.04

[a] w,x,y,z within a row, least squares means lacking a common letter differ ($P<0.01$).
[b] Kidney fat reported as a percentage of the chilled carcass weight.
[c] Yield Grade = (10×adjusted fat thickness, in) + 0.4.
[d] Retail product yield = 49.94−0.085×hot carcass wt., 1b)−(4.376×adjusted fat thickness, in)−(3.53×body wall thickness, in. + (2.456×*longissi-longissimus thoracic* area, sq. in).

of DX carcasses, but larger ($P<0.01$) than the LT areas from carcasses of St. Croix-sired wethers (Table 2). When LT area was expressed on a chilled carcass weight basis, carcasses from DX lambs tended to be more heavily-muscled ($P<0.10$) than DS, SC, and SX carcasses. Even though carcasses from SC lambs were trimmer, calculated retail cut yield was not affected by breed-type.

Dorset lambs produced carcasses with larger LT areas than St. Croix and Katahdin lambs (Horton & Burgher, 1992), and both Solomon et al. (1991) and McClure et al. (1991) reported that St. Croix lambs had smaller LT areas than Targhee. However, neither Foote (1983) nor Godfrey and Collins (1999) noted a difference in LT area between St. Croix and wool or wool hair lambs. Even though LT area was not measured, Nell (1998) reported that carcasses from Dorper-sired lambs were heavier muscled, as evidenced by higher leg conformation scores, than carcasses from Suffolk-, Arcott-, Finnsheep×Targhee-, and Rambouillet-sired lambs. Although Dorper-sired lambs had a slight advantage in weight of trimmed rack, loin, and leg cuts over Suffolk-sired lambs (Snowder, 1999), Dorper lambs produced carcasses with 5.7 and 8.7% more muscle and 1.2 and 7.2% less fat than carcasses from Romney and Southdown lambs, respectively (De Waal & Combrinck, 2000).

3.3. Carcass quality

Skeletal, lean, and overall carcass maturities were similar ($P>0.10$) among the breed-types; however, carcasses of DS, KA, and SX wethers received higher ($P<0.05$) flank streaking scores than carcasses from SC lambs; carcasses from DX lambs received flank streaking scores intermediate to the other breed-types (Table 3). Carcass conformation scores for DS, DX, and KA carcasses were markedly greater ($P<0.01$) than the scores attributed to carcasses from St. Croix-sired wethers. The combination of flank streaking and conformation resulted in carcasses from Dorper-sired lambs receiving higher ($P<0.01$) quality grades than carcasses from St. Croix-sired lambs, especially the purebred SC lambs. Although L^* values were similar ($P>0.10$) among the hair sheep breed-types, the LT from SC lambs was less ($P<0.01$) red (lower a^* value), less ($P<0.01$) yellow (lower b^* value), and less ($P<0.01$) total color than the LT from DX, KA, and SX lambs.

Because most of the hair sheep research has been conducted outside of the USA, very little carcass quality information is available. However, the LT from St. Croix lambs had similar marbling scores and quality grades to wool breed lambs, which were significantly greater than those for Barbados lambs (Ockerman et al., 1982). Quality grades for carcasses of Dorper-sired lambs were not different from Suffolk-, Arcott-, Finnsheep×Targhee-, or Rambouillet-sired lambs (Nell, 1998). Moreover, the LT from Katahdin lambs contained substantially more intramuscular lipid than the LT from Barbados Blackbelly, St. Croix, and Dorset lambs (Horton & Burgher, 1992).

Cooking loss percentages were greatest ($P<0.01$) for LT chops from KA lambs (24.8%) and least ($P<0.01$) for LT chops from DX lambs (16.6%: Table 3). Although shear force values for LT chops from DS, DX, SC, and SX lambs were similar, chops from KA lambs

Table 3
Least squares means for carcass quality characteristics of Dorper × St. Croix (DS), Dorper × Romanov × St. Croix (DX), Katahdin (KA), St. Croix (SC), and 3/4 St. Croix-1/4 Romanov (SX) wethers[a]

Item	Hair sheep breeds					Pooled SE
	DS	DX	KA	SC	SX	
Skeletal maturity[b]	170.0	162.2	161.3	158.8	166.3	12.73
Lean maturity[b]	170.0	160.0	167.3	158.8	158.8	16.09
Overall maturity[b]	170.0	161.1	164.3	158.8	162.5	9.96
Flank streaking[c]	597.1v	517.8vw	524.7v	432.5w	561.3v	104.02
Conformation[d]	12.0x	12.0x	11.2x	9.8y	9.5y	1.29
Quality grade[d]	13.4x	13.1x	12.8xy	11.4z	12.0yz	1.08
CIE L^*[e]	35.24	34.62	34.61	35.30	34.77	1.719
CIE a^*[e]	18.53yz	21.42x	20.27xy	17.17z	21.04xy	2.700
CIE b^*[e]	18.09yz	20.45x	19.13xy	16.56z	21.42xy	2.452
Saturation index[f]	25.90yz	29.62x	27.88xy	23.87z	29.32xy	3.601
Cooking loss,%	20.8y	16.6z	24.8x	20.3y	19.3yz	3.22
Shear force	2.53y	2.42y	3.65x	2.23y	1.86y	1.007

[a] v,w within a row, least squares means lacking a common letter differ ($P<0.05$); x,y,z within a row, least squares means lacking a common letter differ ($P<0.01$).
[b] 100–199 = A maturity lamb.
[c] 200–399 = Small; 400–499 = Modest; 500–599 = Moderate; and 600–699 Slightly abundant.
[d] 9 = high Good; 10 = low Choice; 11 = average Choice; 12 = high Choice; 13 = low Prime; and 14 = average Prime.
[e] CIE L^* values measure darkness to lightness (larger values indicate lighter color); CIE a^* values measure redness (larger values indicate redder color); and CIE b^* values measure yellowness (larger values indicate more yellow color).
[f] Saturation index is a measure of meat chroma (larger values indicate more vivid color).

were tougher, as indicated by higher ($P<0.01$) shear force values, than chops from all other hair sheep breed-types. The hair sheep influence may increase tenderness of lamb chops as Warner–Bratzler shear force values for rib chops aged 10 days were 1.1 kg lower for Dorper-sired than Suffolk-sired lambs (Duckett et al., 1999).

4. Conclusions

Although the rate of growth from birth to weaning was similar for Dorper-sired and Katahdin lambs, results of the present study demonstrate that gain was greater for Dorper-sired compared to St. Croix-sired and Katahdin lambs from weaning to harvest. The use of Dorper rams improved carcass weight and muscling when used on St. Croix and Romanov×St. Croix ewes, and appear to be excellent hair sheep sires to produce carcasses that would appeal to the traditional lamb markets in the USA. However, St. Croix-sired lambs, albeit trimmer, may continue to be discriminated against in traditional markets because of their lighter-weight, lighter-muscled, low quality carcasses.

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